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Examination of the biology textbook for 10th grades in high school education and the ideas of the pre-service teachers

E. Omca Çobanoğlu[a,*], Birgül Şahin[b], Çiğdem Karakaya

[a] *Ondokuz Mayıs University, Faculty of Education, Samsun, Turkey*
[b] *Ondokuz Mayıs University, Graduate School of Natural and Applied Sciences, Samsun, Turkey*

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Abstract

This study aims to examine the biology textbook for 10th grades, which is prepared by the Ministry of National Education. The present research is based on qualitative research techniques and includes two steps. In the first step, the textbook misconceptions, question types, contents topics, visual materials and measurement and evaluation techniques are investigated. In the second step, the learning approach of the textbook is evaluated by the five pre-service teachers in the last grade. The results show that important misconceptions, which can affect the learning, are found in biology textbook. As no different types of questions are seen, the textbook can't provide the inquiry according to its questioning techniques. Besides these it is emphasized by the pre-service teachers that the textbook encourages the students to memorize and that the textbook should be revised as a result. In the light of these results the items that how a textbook must be analyzed and which points are to be observed by choosing a textbook must be taught to the pre-service teachers.

Keywords: Biology textbook; misconceptions; learning approach; questioning techniques.

1. Introduction

The educational-instructional process in formal education is planned and this process is pursued by following instructional programs that could intermittently change depending on the need. Besides, throughout this process, textbooks that were designed exclusively for each subject matter course are used. Instructional programs and textbook analysis are popular fields of research both in Turkey and abroad. In Turkey, the instructional programs and textbooks in courses like Social Studies, Science and Technology offer materials for many research as their instructional programs were reconstructed at the elementary school level in 2005. While examining instructional programs and textbooks; various topics are emphasized like misconceptions, content of the textbooks, its alignment with the constructivist approach and the measurement –assessment techniques which is claimed to be projected on the instructional programs after the changes in 2005. For instance, having examined the draft curriculum of the 6th grade science and technology, Taşkın et al (2005) found that the nature of science is disregarded and alternative measurement techniques are not utilized; moreover, that the program does not sufficiently align with the

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constructivist approach. It is possible to stumble on many researches made on instructional programs and textbooks at the elementary school level. The issues encountered in the textbooks at the elementary school level have served for the opportunity to examine the 10th grade biology textbook in order to determine the criteria that the elementary level textbooks bear and the issues faced in these studies made at the elementary school level.

Within biology education, studies that examine the biology textbooks are often found in national and international literature. Textbooks playing an important role in effective biology education are fundamental sources of information in terms of the notions of evolution and ecology along with basic biological concepts, scientific research process and experimental activities (Haury, 2000; NRC (National Research Council), 1997; NRC, 1996). It is common to use textbooks in teaching biology (Kuechl, 1995). Studies made abroad indicate that 90% of the teachers actively use textbooks as their main instructional tool and to assign homework (Blystone, 1989; Stake and Easley, 1978). In Turkey, textbooks are used for various reasons like reference sources and assignments as well (Özay & Hasenekoğlu, 2007). According to Kuechl (1995), if a textbook is the main source of information and order of content during biology lessons, then it should appeal to teachers' and students' needs. Teachers find it logical to follow the textbooks in order for the students to learn all the content areas (Kuechle, 1995). However, it was found that students' realities or life were not related to the concepts covered in the textbooks or that students' background knowledge is not related to the new concepts and that these textbooks do not encourage the students to do research (Leonard and Chandler, 2003).

Studies concerning the issues faced in the biology textbooks are found both in the national and international literature. By examining 17 biology textbooks, Jablon (1992) indicated that these textbooks are explicitly alike. Jablon, further stated that although these textbooks cover scientific process skills, and accurate claims about topics like Science-Technology-Society and collaborative learning, they do not completely integrate those strategies; so the experimental activities appear to be like a "*cook book*" and they do not allow the students to do active research. From another perspective, Gottfried & Kyle (1992) indicated that those textbook-oriented teachers are very dependent on the content of the textbooks; that they do not focus on topics like Science-Technology-Society, personal needs and career sensitivity and that they do not spend time on any of these topics; therefore, the central role that the textbooks claim in the educational process prevents the effective science education from reaching to the target demanded level. Lumpe & Scharmann (1991) emphasize that while the experimental activities prevalent in the biology textbooks provide students with such opportunities as manipulating the devices, developing observational skills; the close-ended and rigidly structured activities constrain students' development of higher order scientific thinking skills such as discussion, setting hypothesis and forming their own inquiry. In the biology textbooks, such phenomena as scientific thinking and the nature of science do not take a major role and these subject matters is not well integrated into the other chapters and topics (Gibbs & Lawson, 1992; Taşkın et al, 2005). Moreover, it is also asserted that the relationship represented in the textbooks among hypothesis, theory and law is inaccurate (Gibbs and Lawson, 1992; Taşkın et al, 2005). Brandwein (1981) claims that specific terms found in the textbooks serve as a motivating factor in biology education. However, Chaing-Soong & Yager (1992) state that the students can not perceive and acquire those specialized specific terms used in the biology textbooks. Kuechle (1995) has concluded that topics related to ecology and environmental principles appear in the last sections of these textbooks through examining the concept of ecology found across 12 mostly preferred biology textbooks. Gibson (1996) claims that there are misconceptions on the concept of **"climax**" by examining various different ecology-oriented textbooks. In the textbooks examined, the concept of climax is defined as the last and stable phase of the succession, however, it is not mentioned that succession does not always result in climax. Özay & Hasenekoğlu (2007) pointed to the issues observed in the visual materials found in 3 high school textbooks; and concluded that the visual materials make it difficult for students to comprehend as they are not clear and comprehensible and that the visual presentations don't induce a process of action and logic**.** Likewise, Kearsey & Sheila (1999) emphasize that there are misconceptions about the visual components.

Some of the goals of biology education include individuals' perceptions about nature of science, scientific literacy, comprehension and application of the scientific research process (NRC, 1989). Fundamental regulations like Project 2061 (AAAS, 1989) and National Science Education Standards (NRC, 1996) explain the main points in science education as follows: (1) students should comprehend the nature of science and scientific research process while participating higher cognitive level activities, (2) the concept of science should be expanded to broad themes and students should acquire a few key science terms in depth rather than superficially learning the terms that are not so essential, (3) students should understand the fundamentals of science composed of the historical trends and social

aspects of the scientific enterprise; (4) students should comprehend the meaning of the relationship among science, technology and society (Lumpe & Beck, 1996).

The main step to be taken to lead the biology education up to the demanded level is to stress the importance of the textbooks in the instructional process (Lumpe & Beck, 1996). In order to reshape biology instruction given at the high school level, it is emphasized that the role of the textbook used during instruction should be investigated (Bybee, 1989). Since textbooks constitute one of the main components to provide appropriate application of the biology education, questions as to what criteria the textbooks should represent and how they should be designed, selected and used, are constantly raised. On the basis of these questions, this study presents the examination of the biology textbook (The Ministry of National Education- MEB, 2007) designed at the 10th grade elementary level.

The fact that important misconceptions were experienced while examining the 10th grade biology textbook proves the significance of this study. This study focuses on various different points like systematic unit and topic distribution, questioning techniques, the approach taken by the textbook towards learning, the textbook's alignment with the nature of science, table of contents, visual materials, references used and measurement-assessment. Moreover, it discusses the approach taken by the 10th grade textbook towards learning and its relevance to biology instruction as far as the reconstruction of the educational programs designed at both the elementary and high school levels is concerned.

In light of the points mentioned above, this study fundamentally aims to a) determine the misconceptions prevalent in the textbook b) discuss the appropriateness of the questioning techniques and c) examine the particular textbook according to its instructional approach. Given this goal, the biology textbook was scanned in great detail at the page and unit level and content analysis was conducted. At the same time, the criteria identified by National Research Council (NRC, 1990, pp. 28-29) were considered to a significant extent. The criteria to be considered while examining the Biology textbook are clearly mentioned: "(1) Adequate but not encyclopedic coverage, (2) Factual accuracy, (3) Incorporation of current conceptual understanding and new subject matter, (4) Logical coherence, (5) Clarity in explanation and effectiveness of illustrations, (6) Appropriateness to students' level and interest, (7) Representation of biology as an experimental subject". This study differs from other studies in that it examines the concerning textbook in great detail and bases its examination on the criteria set by such a critical institution like National Research Council. The current study bears significance as it is the first one that presents this type of examination.

2. Method and findings

The current study is qualitative and composed of two stages. In the first stage of the study, the document analysis of the 10th grade Biology textbook published by the Ministry of National Education was conducted (Yıldırım & Şimşek, 2005). In doing so, the textbook was attentively read. The misconceptions, question types, content, visual materials and measurement-assessment techniques that appear on the textbook were evaluated. Hereby, the accurate definitions as opposed to misconceptions, alternative question types were systematized and recommended by the researchers. As for the second stage, one-by-one interviews were conducted. Also, the participants of this study were 5 pre-service teachers who were trained at the biology teacher education programs and who closely followed the corresponding biology textbook. The participants offered their views on the textbook's approach towards learning, its readability, reliability, and all the other criteria as mentioned above. Moreover, the textbook's alignment with the nature of science and its usability in instructional processes was questioned with the participation of the pre-service teachers. Interviews lasted for 30 to 40 minutes (Merriam, 1998).

The results of the study are briefly stated as follows:

1. Stage: The document analysis of the 10th grade biology textbook

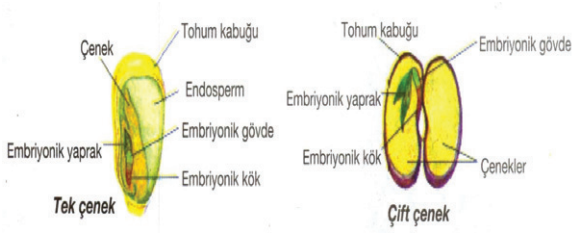
Subject Matter Content: Content details and distribution are shown on Table 1. As the content was fractured, the relationship among the units was disregarded. An order distant from a holistic approach was followed. For instance, the close relationship between the section on "Opinions on the birth of life" and the "Ecology" was not examined. Subject matter contents are not sufficient. Further with the examples, such contents within the unit of "Ecology" as "Life unions in Biosphere" and "life unions inland and in water" were just mentioned by the title (p. 45). Moreover,

the following statement used within the same unit "terrestrial and in water life unions within the biosphere bear population, community and ecosystem" causes both misconceptions and conceptual confusion (p. 45). Primarily, the unions of land and water life elements are already an ecosystem and community in the biosphere (Kışlalıoğlu & Berkes, 2003; Yıldız et al, 2000). Population, community and ecosystem are parts of the ecosphere while constituting the area of study (Kışlalıoğlu & Berkes, 2003; Yıldız et al, 2000). Similar examples are often found in the textbook. Again, the units on "Reproduction" and "Development and Growth" were presented without building any mutual relationship. Principles ordering the content and units from simple to complex, from concrete to abstract and from familiar to distant were not taken into consideration.

Table 1Subject matter content of the textbook and subject matter distribution

Chapters	Subject matter distribution
1: Biology as a Science	What is the Science?, Characteristics of the Scientists, Scientific Method "Learning Think and Search", Nature of Biology, History of Biology, Subdisciplines of Biology, Application Areas of Biology, Relationship between Biology and other Disciplines, Laboratory Studies
2: Ecology "World and Living Things"	Living Things and Environment, Biotic and Abiotic Elements of Environment, Nutrient Cycles, Life Unions on Biosphere, Environment Pollution, Environment Protection
3: Behavior of Living Things	Definition and Mechanism of Behavior, Natural Behaviors of Animals, Acquired Behaviors, Synchronizer (Biological Clock), Social Behaviors
4: Ideas on the Birth of Life	Ideas on the Birth of Life, Ideas on Evolution
5: Reproduction	Asexual Reproduction, Sexual Reproduction, Sexual Reproduction on Flowering Plants, Fertilization on Animals, Reproduction System of Men, Health of Reproduction System
6: Development and Growth	Development and Growth of Plants, Elements that effect the Growth of Plants, Development and Growth of Animals, Anomaly of Growth, Specific Growth Phases of Multicelluar, Cell and Tissue Cultures, Tissue and Organ Transplantation, Length of Life of Living Things

Visual Materials: The pictures are mostly drawn, for instance, there are not many real pictures of the scientists or animals and plants in the nature (pp. 14, 20, 80). The print quality of the visuals is low. Important incompatibilities between the visual elements and the text are observed (Figure 1).



What was named as "Monocotyledon and dicotyledonous plants" seed structures and the comparison of these structures" was stated as embryonic stem and body within the text (p. 112).

Figure 1. Incompatibility between the visual material and the text

Most of the visual element makes it difficult for the students to learn (Figure 2).

It was intended to show "geothermal energy source" on the picture aside. However, the fact that the print of the picture is bad and there is incompatibility between the text and visual causes difficulties in comprehending the concept (p. 50).

Figure 2. Difficulties in perception on the visuals

Misconceptions: Considering the relationship of the biology discipline with other areas of science, the number of the concepts in the textbook is not sufficient. By doing the encyclopedically definitions of the concepts, conceptual instruction was disregarded. Moreover, the terms were presented one after another without much explication. In the

textbook, models like a concept map showing the relationships amongst the terms do not exist but simple schemes are found (pp. 22, 91). In addition to these, misconceptions along with insufficient information that could influence learning are found. For instance, while presenting the scientific research stages, some of the stages in scientific research were not defined while the names of some others were modified (p. 15). Likewise, while defining the nitrogen cycle, nitrogen fixation was not mentioned (p. 48). We face crucial misconceptions apart from insufficient information. Importantly, the relationship between the theory and the law that constitutes the nature of science was misrepresented (p. 17). On the other hand, it was implied that environment and ecosystem have the same definitions by misrepresenting the concepts like environment and ecosystem (p. 36). Misconceptions prevalent on the textbook are shown on table 2.

Table 2Example cases concerning misconceptions prevalent in the textbook

Chapters	Misconceptions	Recommended Definition
1	**Theory:** Theory is a hypothesis that has been constantly supported by evidences (s.17). **Law:** When a theory has been merged a universal characteristic and scientific facts, it becomes a law (s.17).	**Theory:** "A collection of general propositions (postulates, assumptions) that when taken together attempt to explain a class of related phenomena (Lawson, 1995)". **Law:** "A general proposition that summarizes a pattern of regularity detected in nature-that is, the manner or order in which a set of natural phenomena occur under certain conditions (Lawson, 1995)".
2	**Environment:** Environment is an outdoor place that people and other living things carry on their life (s.36). **Ecosystem:** In nature living things lived in a certain area and their relationships with all biotic and abiotic elements compose an ecosystem (s.47).	**Environment:** "All external conditions and factors, living and non-living (chemicals and energy), that affect an organism or other specified system during its lifetime (Miller, 1992)". **Ecosystem:** "An ecosystem is a complex of producers, consumers, decomposers, and detritivores and the physical environment, interacting through energy flow and materials cycling (Starr and Taggart, 1992)".
3	**Reflex:** Reflex is sudden and constant reactions in response to effect (action) that has been seen on living things (s.66). **Stimulus:** An exchange that occur indoor or outdoor, cause a change that is seen on living things (s.64).	**Reflex:** "A simple, stereotyped, and repeatable movement elicited by a sensory stimulus (Starr and Taggart, 1992)". **Stimulus:** "A specific form of energy, such as light, heat, and mechanical pressure that the body can detect through sensory receptors (Starr and Taggart, 1992)".
4	Darwin's hypothesis of **natural selection** tries to explain how a new species develop from previous species (s.82).	Firstly, **natural selection is a phrase, not a hypothesis** (Lawson, 1995). "**Natural selection** happens when some individuals in a population survive and reproduce more successfully than others because of their inherited traits (Cartwright et al, 2000)".
5	**Vagina:** Vagina is a vestibule that unfertilized ovum is got thrown out (s.99)	**Vagina:** "Part of a female reproductive system that receives sperm, forms part of the birth canal, channels menstrual flow to the exterior (Starr and Taggart, 1992)".
6	**Placenta:** Villuses and womb wall tissues constitute placenta. (s.123).	**Placenta:** "Of a uterus, an organ composed of material tissues and extra embryonic membranes (chorion especially), delivers nutrients to and carries away wastes from embryo (Starr & Taggart, 1992)".

Question Types: There are no definite and systematic question types in the textbook. The questions are given under the titles "measurement and test" at the end of each unit. Majority of the questions within the measurement sections are one-dimensional and the number of why/how questions and multidimensional questions are limited. In the test section, there are multiple choice questions. Generally, there are content knowledge questions that do not inquire the cause-effect relationships and the answers to the questions could easily be found throughout the unit. This constitutes a problem as it might not allow the students to consult other reference sources. The number of questions at the unit level is shown on table 4. As can be seen on the table, there are sufficient questions in the textbook but these questions primarily aim to measure and assess learning at the end of each unit. Very few questions were rarely observed throughout the text. Moreover, there is no logical order among the questions. Major

instructional models like Bloom's Taxonomy (Bloom, 1984) were not utilized. Some of the questions were shown on table 3.

Table 3Examples for the question types prevalent in the textbook (taken from evaluation sections)

Chapters	One-dimensional Questions	Multidimensional Questions
1	What are the study areas of molecular biology? What is the biology subdiscipline that researches the environmental factors on living things?	How is the relationship between hypothesis, theory and law? Try to solve a problem by using scientific method steps.
2	What is the difference between mutualism and commensalisms? What are the functions of nitrification bacteria?	What is happened that all of decomposers in a ecosystem disappear? Why does the energy decrease passing upper steps in an energy pyramid?
3	What are the natural behaviors of living things? What is the study area of ethology?	Why do understanding of colour of a bee and man show a difference? What is the advantage of own survival land of a living thing?
4	What is the idea of Aristo on active principle? What is the result of Weismann's experiment?	Explain ideas of Darwin on evolution What is the advantage of adaptation on living things?
5	How many are there sexual reproduction? What are the functions of stamen?	Why do fishes spawn lots of egg once a time? Explain the advantage of sexual reproduction versus asexual reproduction.
6	What are the hormones that effect plant development? (s.136) What are the functions of placenta?	Why do plants gravitate towards the sun light? What are the development differences between monocotyledon and dicotyledonous plants?

Table 4Quantitative characteristics for some elements examined in the textbook

	Chapters	1	2	3	4	5	6
Quantity Characteristics							
	Number of Activities	4	2	-	-	4	4
	Number of Questions	29	29	23	26	32	40
Question	**Number of Why/How Questions**	5	7	2	3	3	15
Types	**Number of One-dimensional Questions**	24	22	21	23	29	5
	Number of Concepts	15	60	20	16	75	51
	Number of Misconceptions	5	20	3	3	3	4
	Number of Visual Materials	19	7	7	8	26	24
Number of Measurement Assessment Techniques		2	2	2	2	2	2

Measurement-Assessment Techniques: As was mentioned above, single model testing techniques are used. These techniques are given under the title "measurement and test."

Design of the Activity: In the textbook, there are close ended activities that identify the necessary steps to be followed in the experiments as structurally bulleted, and that encourage students to make research and the consequences of which can be predicted. Mostly there are mechanical activities. They are not closely aligned with the nature of science. Although there are stages like identification of the problem, the students are not given the opportunity to identify the problems all by themselves. Stating the goal right upfront in activities takes away all the curiosity and feelings of uncertainty towards scientific inquiry.

Learning Approach: A teacher-centered learning exists. Learning theories were not fully employed and neither behavior-oriented nor process-oriented instruction was presented. Specially, "the nature of science" was stated, however, it is incomplete and inaccurate, and the nature of science stays insufficient in application.

Nature of Science: As stated above, the statements related with the nature of science are weak. The scientific research processes were disregarded even in the experimental activities.

The textbook evaluation according to the NRC (1990) criteria

(1) Adequate but not encyclopedic coverage: The textbook was written in an encyclopedically fashion and so excerpts from the daily life, analogies, daily biologic studies and examples from natural life were not employed. Although there is a great deal of information transfer, it is open to discussion as to what the function of this information is due to such causes as the lack of inquiry and research techniques. It is contended that inquiry techniques, open ended experiment and conceptual pattern will both drift the content apart from the encyclopedically approach and will construct a more meaningful presentation. As was emphasized earlier, constructing alignment and relationships among textbook units, themes and concepts will facilitate learning as well.

(2) Factual accuracy: As encyclopedically information transfer is dominant throughout the textbook, especially the scientific information is based on the realities. However, due to misconceptions and lack of citations or references, the reliability of the textbook is adversely affected.

(3) Incorporation of current conceptual understanding and new subject matter: The fact that there is no holistic approach displayed causes the concepts, terms and units to look fractured into separate pieces. Since conceptual maps that show the relationships among the concepts are not employed, concepts acquired earlier and the new concepts are not meaningfully connected to one another.

(4) Logical coherence: There are some logical mistakes in the textbook. For instance, while defining the concept of "succession", the definition was incomplete; the primary and secondary succession concepts were not defined at all. Succession was implied to be secondary succession. Likewise, the phases of primary succession were not presented, the logical pattern of the succession phenomenon was ignored (p. 47).

(5) Clarity in explanation and effectiveness of illustrations: As mentioned earlier, the print quality of the visual elements was low, insufficient in projecting the reality (Figure 2) and was not compatible with the text (Figure 1).

(6) Appropriateness to students' level and interest: Considering the approach taken by the textbook towards learning, information transfer and readability, it is incompatible with students' levels and interests. Since there are no inquiry techniques and applications of the daily happenings, students' curiosity is not aroused and instruction that is grounded in research does not take place.

(7) Representation of biology as an experimental subject: When the units are considered, biology stays at a theoretical level.

Second Stage: Pre-service Teachers' Opinions

Pre-service Teachers' views could be gathered under four themes.

Physical Condition of the Textbook: Pre-service teachers expressed that the number of pages in the textbook is insufficient. They also mentioned that the print quality was low, discolor and could easily be eroded.

Learning Approach: Participants emphasized that the textbook is encouraged by rote and the teachers could use it as a reference book. At the same time, they think that the textbook was not designed according to any of the learning theories and so does not lead to durable learning.

Content Arrangement: Participants who declared that the content distribution is not systematized and is fractured into piece also said that the relationships among the concepts are weak and also there is no content integrity. Pre-service teachers who think that the activities are few and that the content is not grounded on research constructively criticized the preparatory work given at the beginning of the teacher education program and the evaluation questions presented at the end of their training program. Besides, they drew attention to the accumulation of the texts and insufficiency of the visual materials. They added that there could be misconceptions.

Readability (textbook's language) and Reliability: Participants mentioned that some of the sentences may not be comprehended by telling that the readability of the textbook is weak. For this reason, they do not find the textbook to be reliability but still find it appropriate for the central authority to publish it.

3. Conclusion

In the light of findings given above, it is seen clearly that during preparation of the biology textbook, international standards of science education were disregarded. Because of lack of the scientific research processes and questioning techniques, the textbook is weak and inadequate. Then, the misconceptions in the textbook make this

situation worse. In addition to these results, visual materials are inappropriate and don't serve the goals of topics, there are mechanic activities and measurement-assessment techniques aren't diverse. So, it is clear that the textbook don't serve to meet the needs of teacher, students, and even instruction. As a consequence, since the nature of science and questioning are altogether disregarded, it was designed in an inadequate manner. Lack of the usage of major learning approaches results in useless information which is far away from investigation. The quotation from popular science magazines shows that the references used in the book is far away from scientific manner. Moreover, the ideas of pre-service teachers' supports the results of the study and this makes clear that the textbook should be revised and prepared according to the international standards of science education.

Thinking these basic results a textbook must have certain aims. Firstly, textbook should be helpful to understand the main scientific concepts easily. Main scientific concepts should be presented deeply in the textbook, but the presentation should not bring on misconceptions. Secondly, history of science, nature of science, and science and technology, society issues should be perceived as an intellectual and social aim. At last, scientific research processes, questioning, inquiry based instruction and problem solving skills should be supported by the book. Biology education provides discussion settings to students for important science topics in the classroom. For example students can investigate the environmental problems which they become face to face in the area that they live. They can try to search the importance of a wetland near their neighborhoods. And they can save and help to protect the extinct and endangered species. Textbooks that are important part of biology education should encourage the students for investigating on diverse subjects using the questioning techniques, instruction approach, visual materials and activities.

In light of these results, during the teacher training processes, pre-service teachers should be given the opportunity to acquire how to analyze the textbooks and what specific principles to be careful about in textbook selection.

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